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Response of Fertigation and Foliar Sprays on Yield and Fruit Quality of Papaya Variety Surya

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ABSTRACT

Background: Papaya (*Carica papaya* L.) belonging to Caricaceae family has long been recognized as a wonder fruit of the tropics and grown predominantly for its delicious taste and extraction of its digestive constituent papain. As vegetative growth and flowering is simultaneous in this crop, supply of requisite amount of nutrients is necessary during the active growth period, which is possible through fertigation. Knowledge on correct dose of fertilizers to be provided through fertigation is very crucial.

Methods: A field experiment was conducted during the period 2018-2020 at Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram to investigate the response of fertigation and foliar spray on yield and fruit quality of papaya variety Surya. The experiment was laid out in randomised block design with combination of four fertigation doses of 75%, 100%, 125% and 150% RDF of N and K and three foliar sprays (1% 19:19:19, 0.5% $ZnSO_4$+0.3% borax and water spray) which where compared with soil application of recommended dose of NPK (control 1) and soil application of NPK plant^{-1} year^{-1} based on soil test data as organic manures as combination of FYM, poultry manure and vermicompost in the ratio of 2:1:1 (control 2).

Result: The findings of the study revealed that application of 100% RD of N and K through fertigation at weekly interval from one MAP to 20 MAP and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax at 4th, 8th, 12th and 16th MAP (T_5) along with basal application of 850 g rock phosphate and 15 kg FYM improved the yield and fruit quality parameters and can be recommended for commercial papaya cultivation.

Key words: Borax, *Carica papaya* L., Carotenoids, Fertigation, Foliar spray, $ZnSO_4$.

INTRODUCTION

Papaya (*Carica papaya* L.) is one of the most cultivated tropical fruit crops, which gained popularity due to its nutraceutical properties. India with an area of 1.39 lakh hectares and production of 58,31,000 million tons is the leading producer of papaya in the world (NHB, 2019). It is slowly emerging from the status of a homestead crop to that of commercial crop in Kerala. So there is a pressing need to enhance its productivity by optimal use of fertilizer, water and other inputs. Conventional method of nutrient application followed in papaya leads to the loss of nutrients and reduction in nutrient use efficiency. Applying fertilizer through an efficient method offers a vast potential for more accurately and timely crop nutrition and it provides an accurate and uniform application of nutrients to the wet areas, where the active roots are concentrated (Kafkafi and Kant, 2004).

Fertigation facilitates irrigation along with fertilizers to the crop plant is well recognized as the most effective, economical and convenient means of maintaining optimum fertility and water supply according to the specific requirement resulting in higher yields and better quality fruits (Syvertsen and Smith, 1996). Jeyakumar *et al*. (2010) reported positive influence of fertigation on plant growth, yield and quality of papaya. Nisha *et al*. (2020) found that yield of watermelon increased under drip irrigation and fertigation than the conventional surface irrigation and soil application of fertilizer. Knowledge on correct dose of fertilizers to be supplied through fertigation is very important in enhancing the productivity.

Apart from that, deficiencies of zinc and boron had been increasingly reported in papaya. Foliar nutrition of micronutrients will be very helpful to overcome this problem. The foliar sprays of zinc along with boron increases the fruit yield and latex yield, apart from improving the quality traits in papaya (Misra *et al*., 2003). Keeping in view the importance and future possibilities of incorporation of fertigation and foliar sprays into the farming system, an experiment was conducted to standardize nitrogen and potassium fertigation doses and foliar sprays with micronutrients in papaya variety Surya.

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MATERIALS AND METHODS

A field experiment was conducted at Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram,

Kerala from June 2018 to February 2020 to study the influence of fertigation and foliar nutrition on growth and yield of papaya variety Surya.

The experiment consists of 14 treatments replicated thrice, which was laid out in Randomised block design. Gross plot size was 24 m^2. Six plants were maintained per plot, thus a total of 252 plants were maintained for the experiment. Fertigation treatments were fixed based on the N and K recommendation as per KAU POP (Kerala Agricultural University, Package of Practices) based on soil test data (187:170:341 g NPK $plant^{-1}$ $year^{-1}$) for papaya. Three foliar sprays (1.0 % 19:19:19 at bimonthly interval starting from 4 MAP to 16 MAP, 0.5% $ZnSO_4$ + 0.3% borax at 4th, 8th, 12th and 16th MAP and water spray at bimonthly interval starting from 4 MAP to 16 MAP) were also used with different levels of fertigation. These where compared with soil application of recommended dose (RD) of NPK (187:170:341 g NPK $plant^{-1}$ $year^{-1}$ based on soil test data) (control 1) and soil application of 187:170:341 g NPK $plant^{-1}$ $year^{-1}$ based on soil test data as organic manures as combination of FYM, poultry manure and vermicompost in the ratio of 2:1:1 (control 2). Treatment details are given below:

Treatment details
T_1 75% RD of N and K through fertigation and foliar sprays of 1.0% 19:19:19.
T_2 75% RD of N and K through fertigation and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax.
T_3 75% RD of N and K through fertigation and water spray
T_4 100% RD of N and K through fertigation and foliar sprays of 1.0% 19:19:19.
T_5 100% RD of N and K through fertigation and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax.
T_6 100% RD of N and K through fertigation and water spray
T_7 125% RD of N and K through fertigation and foliar sprays of 1.0% 19:19:19.
T_8 125% RD of N and K through fertigation and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax.
T_9 125% RD of N and K through fertigation and water spray
T_{10} 150% RD of N and K through fertigation and foliar sprays of 1.0% 19:19:19.
T_{11} 150% RD of N and K through fertigation and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax.
T_{12} 150% RD of N and K through fertigation and water spray
T_{13} Control 1 - KAU POP (187:170:341 g NPK $plant^{-1}$ $year^{-1}$ based on soil test data, soil application of nutrients with conventional land management).
T_{14} Control 2 - Organic POP (187:170:341 g NPK $plant^{-1}$ $year^{-1}$ based on soil test data as organic manures as combination of FYM, poultry manure and vermicompost in the ratio of 2:1:1.

Organic manure (15 kg FYM $plant^{-1}$) was given uniformly to all treatments as basal. Basal soil application of lime and rock phosphate (500 g and 850 g respectively based on soil test data) was applied uniformly for all treatments except controls. Urea and Muriate of Potash (MOP) were used as fertilizer sources for fertigation applied weekly from 1 MAP to 20 MAP.

The observations were recorded on plant height, girth, number of leaves at 8, 12 and 16 months after planting (MAP) and leaf area index at 6, 12, 18 and 20 MAP. Five fruits were taken from each observation plants to assess the physical parameters such as fruit weight, length and girth. Observations were also recorded on fruit set percentage, number of fruits per plant, total yield per plant. Three fruits were taken from each observation plant to assess the fruit quality parameters such as total soluble solids, acidity, total carotenoids, ascorbic acid, total sugars, reducing sugars and non reducing sugars. Total Soluble Solids (TSS) was determined by using hand refractometer. Acidity, carotenoids, total sugars, reducing and non reducing sugars were determined as per the procedure suggested by Ranganna (1997). Ascorbic acid content was estimated as per the procedure suggested by Sadasivam and Manickam, (1996).

Statistical analysis

The data was analysed statistically by applying the techniques of analysis of variance (Panse and Sukhatme, 1985).

Results and Discussion

Biometric parameters

The data pertaining to plant height, girth, number of leaves at 8, 12 and 16 MAP of plants as affected by fertigation and foliar sprays is presented in Table 1. The data clearly indicates that the effect of treatments on plant height, girth, number of leaves was significant.

Among the treatments, T_4 registered highest plant height, plant girth and more number of leaves after 8, 12 and 16 MAP (190.23 cm, 236.40 cm and 262.56 cm plant height, 39.33 cm, 51.65 cm and 56.92 cm plant girth and 22.34, 31.22 and 25.11 leaves respectively after 8, 12 and 16 MAP). Similar result of enhanced plant height under 100% fertigation was reported by Agrawal *et al*. (2010) in papaya cv. Red Lady. Increased uptake of nutrients, nitrogen and potassium under optimum dose of fertigation and foliar sprays of 1.0% 19:19:19 might have contributed to expansion of stem girth.

Data on leaf area index recorded at 6, 12, 18 and 20 MAP showed significant variation among treatments (Table 2). Highest leaf area index of 1.71, 4.20, 2.43 and 2.28 was recorded in T_4 at 6, 12, 18 and 20 MAP respectively. Higher leaf area index in T_4 may be due to optimum availability of major nutrients throughout the crop growth period by increased split application through fertigation in relatively smaller quantity in addition to the foliar application of 19:19:19. Shimi (2014) reported that foliar application of 19:19:19 at 4 and 6 MAP significantly increased the leaf area index in banana cv. Nendran.

Yield parameters

Data on fruit weight, fruit length, fruit girth, fruit set percentage, number of fruits per plant and total yield per

plant of papaya recorded in Table 2 exhibited significant differences among treatments.

Significantly highest fruit weight, fruit length and fruit girth (797.51 g, 16.90 cm and 13.90 cm respectively) was noticed in T_4. It was found to be on par with T_5 with 792.42 g fruit weight, 16.79 cm fruit length and 13.74 cm fruit girth. Treatments receiving optimum doses of nutrients through fertigation and different foliar sprays were found to have highest fruit weight, length and girth. Application of 100% RD of N and K through fertigation might have first improved the internal nutritive condition of plant leading to increased growth and vigour associated with photosynthesis, by which the applied nutrients accelerated mobility of photosynthates from source to sink as influenced by the growth hormones and finally translocation of assimilates into the fruits (Sharma *et al*., 2013) thereby increasing the fruit weight.

It is evident from Table 2 that data on fruit set percentage, number of fruits per plant and total yield per plant of papaya differed significantly among treatments. Among different treatments, highest fruit set (86.27%), more number of fruits (48.11) and highest yield (38.30 kg plant^{-1}) was recorded in T_4, which was on par with T_5 in all the parameters (85.43% fruit set, 47.45 fruits and 37.60 kg plant^{-1} yield). Higher yield per plant obtained in treatments T_4 and

Table 1: Effect of fertigation and foliar sprays on plant height, girth and number of leaves of papaya variety Surya.

Treatments	Plant height (cm)			Plant girth (cm)			Number of leaves		
	8 MAP	12 MAP	16 MAP	8 MAP	12 MAP	16 MAP	8 MAP	12 MAP	16 MAP
T_1	165.14	208.55	235.36	30.04	40.00	46.09	19.67	26.22	19.78
T_2	162.81	205.27	233.49	28.57	37.94	44.20	19.22	23.89	19.00
T_3	144.09	176.52	201.73	21.86	30.92	36.48	14.89	16.56	11.67
T_4	190.23	236.40	262.56	39.33	51.65	56.92	22.34	31.22	25.11
T_5	184.50	230.15	258.28	37.46	49.99	55.17	21.78	29.33	23.00
T_6	158.76	199.98	224.41	28.00	37.01	43.41	17.89	21.00	17.22
T_7	171.46	221.62	250.96	32.94	45.27	50.16	20.78	27.66	21.22
T_8	175.71	226.05	254.72	34.30	48.90	52.97	21.56	29.22	21.78
T_9	161.01	201.64	229.38	30.03	39.99	45.69	18.44	23.11	17.78
T_{10}	155.38	194.23	217.76	24.01	32.01	37.58	17.67	19.45	14.33
T_{11}	170.76	219.33	244.30	32.88	43.91	49.79	20.11	26.66	21.22
T_{12}	151.02	183.54	210.12	23.94	31.00	37.53	16.00	19.11	12.67
T_{13}	153.53	185.69	213.50	26.19	35.17	38.92	17.22	19.78	14.00
T_{14}	167.88	209.19	238.30	30.70	39.73	44.00	19.89	26.67	20.00
SEm (±)	0.74	1.38	1.19	0.39	0.42	0.42	0.48	0.36	0.34
CD (5%)	2.14	4.02	3.45	1.15	1.21	1.23	1.38	1.07	0.97

Table 2: Effect of fertigation and foliar sprays on leaf area index, fruit weight, fruit length, fruit girth, fruit set percentage, number of fruits. per plant and total yield per plant of papaya variety Surya.

Treatments	Leaf area index				Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Fruit set (%)	Number of fruits per plant	Total yield per plant (kg)
	6 MAP	12 MAP	18 MAP	20 MAP						
T_1	1.45	3.60	1.97	1.91	708.93	14.60	11.83	80.57	41.00	29.06
T_2	1.39	3.44	1.93	1.87	703.47	14.45	11.13	79.34	40.11	28.21
T_3	1.18	2.71	1.55	1.52	569.84	9.15	7.86	64.50	28.45	16.21
T_4	1.71	4.20	2.43	2.28	797.51	16.90	13.90	86.27	48.11	38.30
T_5	1.62	4.11	2.34	2.23	792.42	16.79	13.74	85.43	47.45	37.60
T_6	1.50	3.27	1.79	1.76	634.60	13.03	9.98	75.13	37.22	23.62
T_7	1.58	3.95	2.11	2.05	747.95	16.09	12.74	82.12	44.33	33.16
T_8	1.58	4.00	2.25	2.13	754.60	16.31	12.98	83.18	45.00	33.96
T_9	1.54	3.31	1.82	1.78	644.11	13.37	10.20	77.25	38.44	24.76
T_{10}	1.33	3.14	1.70	1.64	631.38	10.98	8.96	70.87	33.78	21.33
T_{11}	1.57	3.85	2.03	1.97	741.49	15.62	12.68	81.47	42.00	31.14
T_{12}	1.19	2.83	1.56	1.53	592.45	9.89	8.45	66.70	30.00	17.78
T_{13}	1.22	3.05	1.71	1.69	608.71	10.43	8.51	70.20	34.55	21.03
T_{14}	1.50	3.79	1.98	1.94	711.31	15.01	11.90	80.80	42.56	30.27
SEm (±)	0.02	0.07	0.02	0.02	2.80	0.14	0.16	0.57	0.40	0.32
CD (5%)	0.06	0.20	0.07	0.06	8.13	0.41	0.46	1.67	1.15	0.93

Table 3: Effect of fertigation and foliar sprays on total soluble solids, acidity, total carotenoids, ascorbic acid, total sugar, reducing sugar and non reducing sugar content of papaya variety Surya fruits.

Treatments	Total soluble solids (°Brix)	Acidity (%)	Total carotenoids (mg 100 g^{-1})	Ascorbic acid (mg 100 g^{-1})	Total sugars (%)	Reducing sugar (%)	Non reducing sugar (%)
T_1	13.15	0.26	1.64	54.36	7.46	6.13	1.32
T_2	13.36	0.23	1.81	57.78	7.80	6.22	1.58
T_3	12.50	0.28	1.46	43.42	7.15	5.97	1.18
T_4	14.73	0.16	2.08	65.30	9.30	7.84	1.46
T_5	15.10	0.13	2.21	68.38	9.66	8.05	1.61
T_6	14.01	0.17	1.92	62.91	8.73	7.21	1.51
T_7	14.43	0.16	2.02	64.96	9.15	7.84	1.30
T_8	14.90	0.15	2.09	67.69	9.45	7.98	1.47
T_9	14.11	0.17	1.96	63.59	8.92	7.45	1.47
T_{10}	13.10	0.26	1.56	51.28	7.45	6.05	1.40
T_{11}	14.32	0.17	1.98	63.93	9.00	7.79	1.21
T_{12}	12.89	0.27	1.49	49.23	7.16	6.03	1.12
T_{13}	13.40	0.22	1.86	58.12	8.15	6.72	1.43
T_{14}	13.61	0.18	1.91	62.22	8.36	6.80	1.56
SE (±)	0.07	-	8.50	1.64	0.03	0.07	0.08
CD (5%)	0.22	0.01	24.71	4.77	0.10	0.19	0.23

T_5 might be due to application of optimum dose of fertilizers through fertigation (100% RD of N and K) in addition to foliar spray with 19:19:19 and $ZnSO_4$+borax, resulting in more preferential influx of photosynthates to the sink contributing to increased fruit weight.

Fruit quality parameters

Effect of fertigation and foliar sprays on fruit quality parameters like TSS, acidity, total carotenoids, ascorbic acid, total sugar, reducing sugar and non reducing sugar content of papaya variety Surya fruits were recorded in Table 3. The data showed significant difference among treatments for all the parameters. Highest TSS (15.10°Brix), lowest titratable acidity (0.13%), highest total carotenoid content (2.21 mg 100 g^{-1}), ascorbic acid content (68.38 mg 100g^{-1}), total sugar content (9.66%), reducing sugar content (8.05%) and non reducing sugar content (1.61%) was noticed in fruits from T_5. The results are in accordance with the findings of Grace (2011) in Kinnow mandarin who reported maximum TSS in treatment provided with 100% NPK as fertigation. Higher total soluble solids observed in T_5 might be due to the efficient translocation of photosynthates to the fruit by regulation of boron. The reduction of titratable acidity of papaya fruits due to foliar application of boron and zinc might be due to their positive influence in conversion of acids into sugars and their derivatives by the reaction involving glycolytic pathway or be used in respiration or both (Pandey *et al*., 2008). Sankar *et al.* (2013) opined that boric acid spray of 0.02 per cent significantly increased the carotenoids content compared to control in mango. Higher ascorbic acid content with application of optimum levels of nitrogen might be attributed to increase in synthesis and catalytic activity of several enzymes and co-enzymes which are instrumental in ascorbic acid synthesis (Boora and Devi, 2000). Results are in agreement with the findings of Babu and Yadav (2005) who reported that application of zinc with boron increased the total sugars percentage in Khasi mandarin. Kumari and Deb (2018) reported that reducing sugar content of pineapple cv. Mauritius was significantly influenced by foliar application of $ZnSO_4$ at 0.5% and borax at 0.5%. Rajesh *et al*. (2016) revealed that the non reducing sugar was significantly influenced with the foliar spray of zinc sulphate in guava cv. Apple Colour.

CONCLUSION

The findings of the study revealed that application of 100% RD of N and K through fertigation at weekly interval from one MAP to 20 MAP and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax at 4th, 8th, 12th and 16th MAP (T_5) along with basal application of 850g rock phosphate and 15 kg FYM improved the yield and fruit quality parameters and can be recommended for commercial papaya cultivation.

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Conflict of interest

All authors declare that they have no conflict of interest.

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